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Identification of Project Risks & Risk Breakdown Structure In Manufacture of Heavy Forgings

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Abstract—
Forging companies, especially in the business of manufacture of heavy forged parts are embedded in the supply chain of critical components of capital goods across various industries. These forged parts form a significant portion of the total raw material requirement of the capital goods equipment and is generally on the critical path of project schedule.Failure to meet delivery schedule poses huge threat to the success of the customer's project.

Delivery of these forged items is delayed in an event of failure to meet customer's quality requirements.Various other uncertainties during the project lifecyclecan also cause delayed delivery. Accordingly, risk management methodologies when employed by the forging supplier to the manufacturing project can result in successful achievement of delivery timelines. The present study is intended to identify the risks (threats) to quality and delivery in manufacture of heavy forged components and create a Risk breakdown structure (RBS) as a reference for further risk planning by the forging supplier.

I. INTRODUCTION

Project Risk management[1] deals with identifying and mitigating the risks right at the planning stage to safeguard the project from foreseen and unforeseenuncertainties which may lead to a deviation from the baseline of scope, time, cost and quality. The risk management planning process includes risk identification and preparation of Risk breakdown structure (RBS), qualitative and quantitative analysis of the risks and planning of risk responses in case of occurrence of particular risk. Risk identification deals with listing out the possible uncertainties that the project may encounter. This involves among other techniques documentation reviews, historical data analysis, brainstorming, Delphi technique, interviewing etc. The output of this process is an exhaustive list of identified risks and its categories.

M.Rasool[2] in his work developed tailor made risk breakdown structure for dynamic risk management of construction projects. Li [3] et.al.in their work established a methodology for identification of risks during construction of large bridges based on WBS and information classification system.

Forged components are generally utilized to meet critical requirements of the equipment. Moreover for large equipment, heavy forged components are assembled to serve crucial service conditions which are usually a combination of extreme mechanical and thermal stresses. These components have to be manufactured as per the stringent specification parameters proposed by the customer. Any deviation in these parameters may lead to a rejection of the component. Also, unlike fabricated or cast components forged parts cannot be repaired. Reworking the component in case of a deviation is also possible only up to some extent. The steel making and forging process are irreversible in most conditions which means failure and possible rejection of the job in case of process non-adherence. This is accompanied by heavy cost overruns for the manufacturer. Moreover, as the testing (both destructive and non-destructive) of forged parts can happen fairly late in the production cycle, any rejection causes huge delays in replenishment of the forged part. Under these circumstances it becomes inevitable for the forging manufacturer to strictly adhere to the manufacturing process to avoid risk of failure.

Owing to the huge impact on cost and schedule of the manufacturing of forged part and in turn project of the customer, appropriate time and resources should be expended in planning risk management sufficiently early during the pre-manufacturing stage itself. However, to ensure robust risk planning an exhaustive list of identified risks is mandatory. Such a database shall contain all the possible uncertainties that the project may encounter and which will cause adverse effect. These risks are further categorized appropriately so that monitoring and control becomesless cumbersome. It is imperative to mention that the risks involves both events whose outcome may be positive (opportunities) or negative (threats). The current study restricts only to threats (negative risks) to successful manufacturing of heavy forged parts.

In the present work, adverse risk (threats) which can result in quality non-conformance or delayed delivery of the forging part are identified and categorized in section II. A Risk breakdown structure for the listed risks is also prepared and shown in section III.

II. RISK IDENTIFICATION AND CATEGORIZATION

A. Methodology

Figure 1 Risk identification methodology

Fig. 1 shows the methodology employed in risk identification process. Documentation review of past projects involving production of forgings was studied. All the deviationswhich resulted in non-conformance to technical requirements or caused delays were recorded.Conditions of uncertainty were identified through brainstorming sessions and perceived risks were recorded. These risks were further validated and its impacts were analyzed. Risks of similar nature were categorized together. Close to 30 to 35 risk categories were identified and were grouped in 7 groups for ease of further risk assessment

B. Category groups of identified risks

Following is the list of risks categories to the product quality and on-time delivery. These are presented in form of groups of risk categories of similar nature which will be further utilized to prepare the Risk breakdown structure in sec. III.

Category Group 3.1 – Risks ofnon-achievement of product requirements like,

1. Mechanical properties requirements as prescribed by the customer or other applicable standard
2. Grain structure, orientation and size, inclusion level and other metallurgical requirements
3. Product not meeting the NDT requirements as prescribed by the customer or other applicable standard
4. Product not meeting the dimensional and surface quality requirements
5. Product not meeting the requirements of chemical composition

Category Group 3.2 – Risks of non-achievement of process requirements like,

1. Steel melting process parameters (liquid metal weight, prescribed slag practice, inert gas purging rate, slag free tapping,Vacuum level requirements in degassing etc.)
2. Ingot teeming parameters (teeming temperature, rate, time lag between two ladle, mould preheat temperature, various mould setting parameters etc.)
3. Forging process parameters (temperature range, forging ratio, as-forged dimensions and other physical parameters like straightness, corner profile, surface discontinuities etc.)
4. Post forging preliminary heat treatment parameters (transformation temperatures, soaking time, cooling method etc.)
5. Heat treatment parameters (temperatures, soaking time, heating & cooling rates and quenching delay etc.)
6. Machining parameters (selection of machine, machining plan and machine parameters for achieving surface finish)

Category Group 3.3 – Risks of non-availability of right resources when required like,

1. Machine (Steel melting equipment, forging press, furnaces, Machine tools etc.) due to planned maintenance or capacity constraint
2. Raw materials and consumables, Power and utilities
3. Technical person, operator, supervisor (from production, engineering and quality department)
4. Customer representative
5. Planning and administrative personnel

Category Group 3.4 – Risks of errors / equipment breakdownduring execution like,

1. Equipment malfunction during processing
2. Human errors during estimation, engineering, production, testing &inspection or documentation etc.

Category 3.5 – Risks from customer like,

1. Change requests after signing of contract (with finalized requirements)
2. Different interpretation of Specification / Code
3. Assumed industry standard of practice not explicitly mentioned in specification
4. Delay or too many iterations to approval of technical and quality plans
5. Appointment of third party inspector with limited accessibility or vicinity
6. Hold imposed on project due to problems faced by the customer in their project
7. Insignificant project expedition measures

Category Group 3.6 – Risks due to organizational process assets like,

1. Established practices and standards that are partially efficient
2. Halo effect - Use ofsame processing methodologysuccessful for another project with/without proper analysis of the differences
3. Data capturedduring previous processing / trials without thorough interpretation of parameters and its relationship affecting the output

Category Group 3.7 – Risks due to enterprise environmental factors like,

1. Low motivation level and less effectiveemployee reward and penalty system
2. Organizations policy on meeting man-power requirements (contract / full-time)
3. Identification of priority of execution amongprojects
4. Robustness and flexibility of work-authorization systems
5. Availability of vendors of raw material
6. Availability and capability of sub-contract service providers
7. Methodology for communication and decision making

The above list presents the major risk categories. There can still be many risks and categories of risk that can be identified with further analysis. However list of risks should be exhaustive,only significant risks should be focused and mitigated.Measure of significance of risk is based upon the probability of occurrence of the risk and its impact on the project success parameters. Accordingly good risk management practice calls for an exhaustive risk register which lists all the probable risks in the project and is updated with new risks being uncovered across various projects.

Probability of occurrence of risks varies based on the situations in which the project is being executed. Accordingly measure of significance of risk is also different for different organizations. An organization with new facility may consider risk 3.3.1 (Non-availability of machine) to be insignificant as the probability of breakdown of machines is very less. However, they may consider risk category 3.7.4 (Robustness and flexibility of work authorization systems) to be significant due to less experience and understanding of the system amongst the employees.

III. RISK BREAKDOWN STRUCTURE (RBS)

[A] Risk Category Group	[B] Risk Category	[C] Risks (Examples)
Category Group 3.1 Risks of non-achievement of product requirements	3.1.1. Mechanical properties requirements	1. Tensile 2. Impact 3. PWHT Simulation 4. Step cooling 5. Fatigue
	3.1.2 Metallurgical requirements	1. Grain structure 2.Grain Orientation 3. Inclusions 4. Phase distribution
	3.1.3 NDT requirements	1. Ultrasonic 2. Magnetic Particle 3. Visual 4. Dye penetrant
	3.1.4 Dimensions and Visual Requirements	1. Length out of tolerance limits 2. Diameter out of tolerance limits 3. Surface roughness not OK
	3.1.5 Chemical Composition requirements	1. Carbon content 2. Alloys content 3. Carbon equivalent requirement
Category Group 3.2 Risks of non-achievement of process requirements	3.2.1 Steel melting process parameters	1. Liquid metal weight 2. Inert gas purging rate 3.Slag free tapping
	3.2.2 Ingot teeming parameters	1. Teeming temperature 2.Teeming rate 3. Time lag between two ladle 4. Mould preheat temperature
	3.2.3 Forging process parameters	1. Temperature range 2.Forging ratio 3.As-forged dimensions
	3.2.4 Post forging preliminary heat treatment parameters	1. Transformation temperatures 2. Soaking time 3. Cooling method
	3.2.5 Heat treatment parameters	1. Process Temperature 2. Soaking time 3.Heating & Cooling rates 4. Quenching delay
	3.2.6 Machining process parameters	1. Selection of machine 2.Machining plan 3. Selection of cutting parmeter
Category Group 3.3 Risks of non-availability of right resources when required	3.3.1 Machine	1. Steel melting equipment 2. Forging press 3. furnaces 4. Machine tools
	3.3.2 Raw Materials	1. Scrap 2. DRI 3. Ferro Alloys 4. Consumables 5. Power 6. Utilities
	3.3.3 Technical resource person	1. Machine Operator 2.Shop Supervisor 3. Technology Engineer 4. Inspector
	3.3.4 Customer representative	1. Customer Inspection personnel 2. Third Party Inspector
	3.3.5 Planning and administrative personnel	1. Shop Planner 2. Project Manager 3. Commercial Manager
Category Group 3.4 Risks of errors / equipment breakdown during execution	3.4.1 Equipment malfunction during processing	1. EAF breakdown 2. Crane breakdown 3. Pumps breakdown
	3.4.2 Human errors during estimation, engineering, production, testing & inspection or documentation etc.	1. Estimate calculation 2. Technical Document preparation 3. Inspection 4. Cutting
Category Group 3.5 Risks from customer	3.5.1 Change requests after signing of contract (with finalized requirements)	1. Dimensions 2. Mechanical properties 3. Delivery schedule 4. Chemistry
	3.5.2 Different interpretation of Specification / Code	1. Testing location 2. NDT methodology 3. Test sample size
	3.5.3 Assumed industry standard of practice not explicitly mentioned in specification	1. Soaking time during heat treatment 2. Depth of sample 3. Unspecified tolerances
	3.5.4 Delay or too many iterations to approval of technical and quality plans	1. QCP approval 2. MPP approval 3. Sampling plan approval
	3.5.5 Appointment of third party inspector with limited accessibility or vicinity	1. Appointment of Individual as inspector 2. Appointment of Inspection agency with office at a distact location
	3.5.6 Hold imposed on project due to problems faced by the customer in their project	1. Force majuere 2. Legislation issues 3. Political issues 4. Local unrest 5. Lack of funds for stage payment
	3.5.7 Insignificant project expedition measures	1. Disallows seemingly unimportant Tests stages to save time 2. Stringent time limit during dispatch inspection
Category Group 3.6 Risks due to organizational process assets	3.6.1 Established practices and standards that are partially efficient	1. Use of specific alloying elements 2. Over-safe machining allowances 3. Insufficient machining allowance
	3.6.2 Halo effect - Use of same processing methodology successful for another project with/without proper analysis of the differences	1. Use of specific alloying elements 2. Soaking temperature 3. Soaking time
	3.6.3 Data captured during previous processing / trials without thorough interpretation of parameters and its relationship affecting the output	1. Heat treatment parameters 2. Reduction ratio 3. Chemical composition
Category Group 3.7 Risks due to enterprise environmental factors	3.7.1 Low motivation level and less effective employee reward and penalty system	1. Lack of drive amongst staff 2. Employee unsatisfied with the reward system 3. Perception of employee that delaying the activity will not be penalised
	3.7.2 Organizations policy on meeting man-power requirements (contract / full-time)	1. Use of Contract man-power in areas where skills are critical. 2. Use of Contract work men in Inspection activity
	3.7.3 Identification of priority of execution among projects	1. Prioritization based on customer relationship 2. Prioritization based on sales value realization 3. Prioritization based on Management discretion
	3.7.4 Robustness and flexibility of work-authorization systems	1. Work-authorization system unable to handle parallel activities 2. Work-authorization system accessible to only senior staff
	3.7.5 Availability of vendors of raw material	1. Less or No vendors supplying material within expected lead time 2. No local vendors for required material 3. No local vendors supplying required quality
	3.7.6 Availability and capability of sub-contract service providers	1. Non-availability of sub-contractors for machining as per requirements 2. Insufficient skilled sub-contractors for machining
	3.7.7 Methodology for communication and decision making	1. Decisions to be made during Fortnightly review meetings only 2. Paper based system for technical documentation and distribution in shops

Table 1 Risk Breakdown Structure

Table 1 shows the Risk breakdown structure which is an output of Risk identification and Categorization process. Risks towards non-conformity of customer quality requirements and timely delivery are listed in Column C. (*This is just an indicative list and not exhaustive one).* These are categorized based on similarity in Column B. The categories are grouped together as category groups in column A.

IV. CONCLUSIONS

In the present work, uncertainties with negative outcome (threats) which may jeopardize projects involving production of heavy forgings in terms of quality and on-time delivery were studied. Historical data, documented technical reports and brainstorming sessions were conducted to prepare an exhaustive list of risks. These were further assimilated together based on similarity of nature into Risk Categories. Risk breakdown structure (to 3 levels) was prepared as an output to this process.

This RBS can be further utilized in subsequent risk assessment process and can be monitored across the life of the project. It can also be utilized as input to planning of new projects of related attributes.

Threat to other project attributes viz. cost, scope, customer satisfaction etc. can also be added into the present structure for further risk planning and control. Risks with positive outcome (opportunities) to the scope, time, cost, quality etc. can also be identified and categorizedin a similar manner.

REFERENCES

[1] Project Management Body of Knowledge PMBOK®, Version 5, Project Management Institute, USA.

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